On the secular variation of the level surface of gravity

by

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(Received: 25th July, 1958)

SUMMARY

It is known that a 50-year period pulsation can be observed in the secular variation of the geomagnetic field as well as in the angular velocity of the Earth.

Author explains these phenomena by the movement of the Earth's core and comes to the conclusion that a similar oscillation must be present also in the secular variation of the observed average sea-level series.

Indeed, using data of different distant mareograph stations, a 50-year period undulation in the trend of the curves can be established. The above phenomena refer to a general worldwide process.

A pulsation of 50 years period was demonstrated in the angular velocity of the Earth by Brouwer (5). The period of this pulsation coincides with that of the secular pulsation of the terrestrial magnetic field (4, 8). The variation in angular velocity cannot be retraced to external astronomical causes, and the mass rearrangements on the surface of the Earth are insufficient to explain the amount of variation (7). The change in angular velocity observed in the time span 1910 to 1930 was so great as to postulate a sinking of the ocean level by 63 cm *(Handbuch der Physik*, **XLVII,** 1956, p. 18). However, no more than one tenth of this level change could be demonstrated even in isolated extremal cases. The assumption that the core is at times advancing, at other times regressing with respect to the surface does not account for the fact of angular velocity variation, it only takes into consideration the consequences of the same. Therefore we are forced to assume the mass rearrangement causing the change to take place in the Earth's interior.

In previous papers the author has pointed out that the Brouwer-period of terrestrial angular velocity goes parallel with the longitudinal wave of the secular variation of the geomagnetic field (3, 4). The author has concluded there that if the longitudinal wave of secular variation is to be felt in the angular velocity of the Earth, the main secular variation should also affect the angular velocity. Moreover, if the individual longperiod variations of the magnetic field are connected with the shift of the Earth's core, the mass rearrangement should cause a variation of the gravity field by a period of similar duration (1). Of course, the gravity measurements of appropriate accuracy are lacking and thus there is not much practical point in advancing this question, but it is to be considered that with a change in mass distribution the shape and spacing of the equipotential surfaces of gravity should also change. These were, as a matter of fact, for a long time past determined with great accuracy by sea level measurements and from the last century measurement series of sufficient accuracy are available. — The value of g may also be changed by an increase of the Earth mass or by a change in its radius, but these effects are so small as to be scarcely demonstrable by data covering one century.

However, the height of sea level is influenced by the effects of stellar mass rearrangements reflected by tidal phenomena, by weather phenomena and currents and finally by the tectonical displacement of the point of observation. The effects of short-period astronomical and climatical influences can, however, significantly be reduced by computing running averages.

The geological movements may be classed in two groups: sudden faulting (as e. g. the change of mean sea level by 133 cm in consequence of the Tokyo earthquake of 1923) and slow level changes of the crust (as e. g. the slow rise of Scandinavia). The sudden movements can be taken into account relatively easily, but the slow level changes may in a period as short as one century affect the general lay-out of the equipotential surfaces.

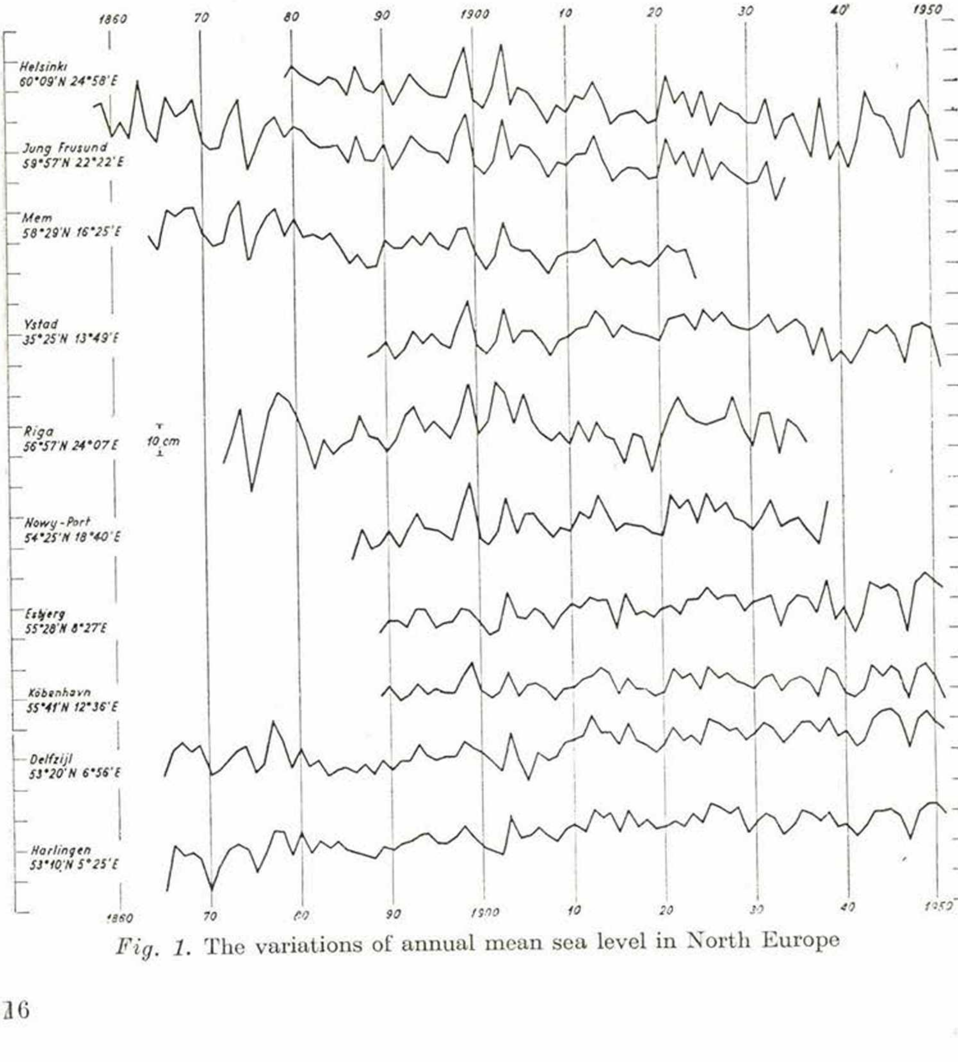

Fig. 1. The variations of annual mean sea level in North Europe

The crucial question is, consequently, whether a period of about 50 years can be demonstrated in the trend of the changes of sea level and if between the trends of stations great distances apart there will be found a certain parallelism or eventually antiparallelism. If so, then the component in question of the sea level undulation can be regarded as an universal, global phenomenon, touching the entire surface of the Earth. However, the number of stations of continuous series or such where the eventual breaks of the series can be overbridged with some exactness is rather small even in worldwide relation.

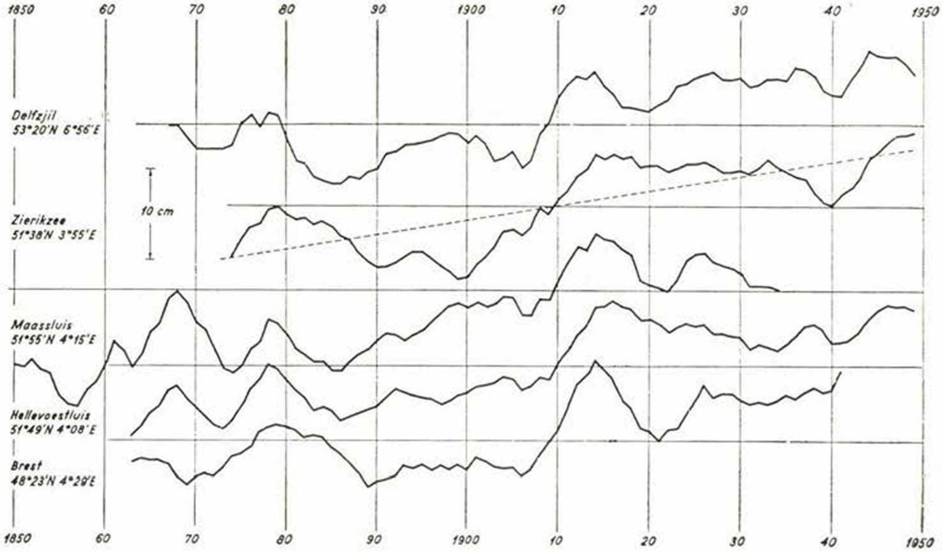

Fig. 2. The variations of sea level as indicated by data from stations of the Netherlands, Belgium and France (five-year running averages). The dotted line indicates the supposed linear variation

In Fig. 1 the series of the annual mean sea levels — i. e. the temporal variation of the sea level — is shown for the North European stations (10). It is remarkable that for all of them the variation is rather capricious around the years 1875, 1900 and 1945, indicating a periodicity of about 40 years. This characteristic is valid for all North Europe and the data of the curves presented are corroborated by a great number of series of other stations not presented here.

Farther south in the Netherlands, Belgium and France the trend of mareograph observations is somewhat different (Fig. 2). The course of the series is analogous, and some stations indicate a definite 50-year period wave. The average trend of the series is rising, as opposed to the North European ones.

The Dunbar station of England exhibits a 50-year period of a decreasing general trend. In Fig. 3 the sea level changes of Sidney, Aberdeen-Dunbar, Honolulu, Bombay, Tunis are shown.

To corroborate the Honolulu curve the series of the Panama stations Cristobal and Balboa were presented. The latter ones point out the fact that the variation shown by Honolulu is valid for an enormous area. The importance of the Honolulu series consists in exhibiting a definite antiparallelism as related to the Dunbar series. The trend of the over-all change is opposite, too ; the data observed in England are decreasing, those of Hawaii, however, rising. It is interesting to note that the Bombay and the much similar Tunis series is also antiparallel to the Dunbar one, while Sidney coincides with the latter with respect to the general trend as well as with respect to the 50-year period. The sea-level curves shown in Fig. 3 definitely exhibit a wave of about

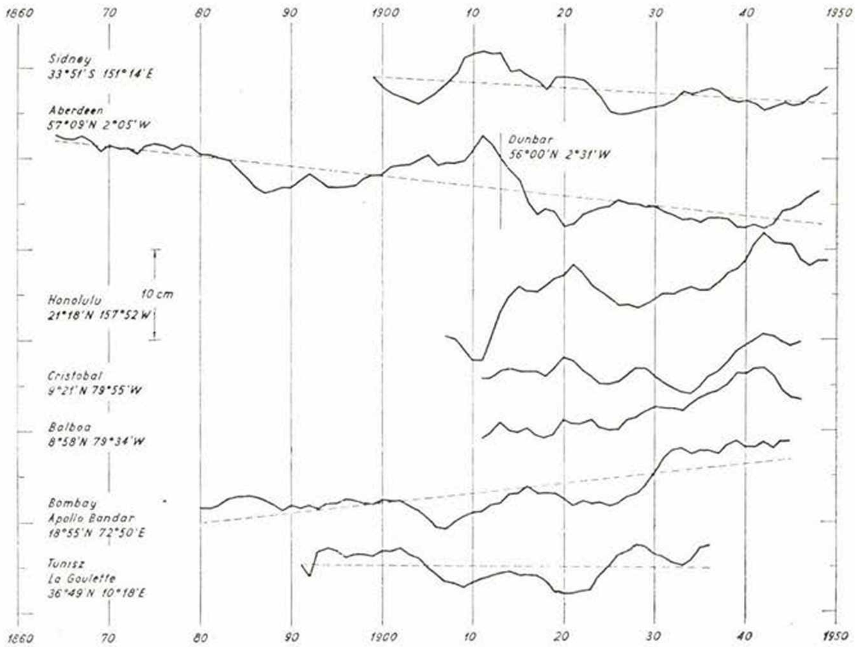

Fig. 3. The variations of sea level at different points of the Earth (five-year running averages). The dotted line indicates the supposed linear variations

50 years period. It is essential that at stations with decreasing general trend of the sea level the 50-year wave has a minimum at the time when at stations with an increasing general trend the 50-year wave is at maximum. Both these extremes coincide with the maximum of the magnetic longitudinal wave (1930). From this it may be concluded that both phenomena may be retraced to one basic cause and that this basic cause possesses such a composite period.

The parallelism and antiparallelism of the sea level changes observed at different points of the Earth surface indicate the fact that in the long-period undulations of sea level a general phenomenon touching the entire Earth is reflected. If the basic phenomenon causing this disturbance should be the supposed shift of the Earth's core perpendicular to the axis of rotation (2), it should have a number of other consequences too. A similar period should have to appear e. g. in the nutation of the Earth. From the investigations of A. Labrouste and Mme Y. Labrouste (6) we know that the undulation of pole height also had a minimum about 1910 and a maximum about

1930, i. e. a period of about 40 years. Summarizing the above said we may state that the secular variation of the terrestrial magnetic field has had

a relative minimum around 1910,
a relative maximum around 1930,
a relative minimum around 1950,

the angular velocity of the Earth has had

a relative minimum around 1910,
a relative maximum around 1930,

and that the amplitude of polar-height undulation has had

a relative minimum around 1910 and
a relative maximum around 1930.

Similarly, the extremes of sea level undulation have also occurred around 1910 and 1930.

The quantitative analysis of the synchronous undulation of the secular variation of the terrestrial magnetic field, the angular velocity of the Earth, the shift of pole height and the sea level changes will be treated in a following paper.

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